[Jpn. J. Parasitol., Vol. 39, No. 6, 612–624, December, 1990]

Some Species of the Genus *Proteocephalus* (Cestoidea: Proteocephalidae) from Japanese Freshwater Fishes, with a Description of a New Species

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(Accepted for publication; February 13, 1991)

Abstract

From Japanese freshwater fishes are reported five species of the genus *Proteocephalus* Weinland, 1858 (Cestoidea: Proteocephalidae): *P. fluviatilis* Bangham, 1925; *P. midoriensis* sp. n.; *P. parasiluri* Yamaguti, 1934; *P. plecoglossi* Yamaguti, 1934; and *P. tetrastomus* (Rudolphi, 1810) Willemse, 1965. All but *P. parasiluri* are described and figured. *P. midoriensis* from *Lefua echigonia* (Homalopteridae) is distinct from the most closely related *P. sagittus* (Grimm, 1872) La Rue, 1911, mainly in more testes arranged in at least two frontal layers, a much less convoluted internal seminal vesicle, a smaller cirrus pouch, rather branched ovarian lobes, more lateral uterine pouches and larger eggs.

Key words: cestodes, a new species, *Proteocephalus*, freshwater fishes, Japan

Cestodes of the genus *Proteocephalus* Weinland, 1858, are intestinal parasites of freshwater fishes (Freze, 1965). This paper deals with the morphology and taxonomy of five species, including a new one, of the genus from Japan.

Materials and Methods

Tapeworms were dissected out of fresh fish, either flattened and fixed with AFA or fixed in hot AFA or hot 10% formalin without flattening, stained with Heidenhain's iron hematoxylin, Delafield's hematoxylin or alum carmine, and mounted in Canada balsam. Some were obtained from formalin-preserved fish and stained with alum carmine or Delafield's hematoxylin. Serial paraffin sections of formalin-fixed worms were cut 10 to 15 μm thick and stained with hematoxylin and eosin. Eggs taken out of formalin-preserved gravid worms were measured. Museum specimens, which had already been mounted in Canada balsam by various fixing and staining methods, were borrowed from the Meguro Parasitological Museum (MPM), Tokyo; the Institute of Taxonomic Zoology (Zoölogisch Museum), University of Amsterdam, Amsterdam; the Institute of Parasitology, Czechoslovak Academy of Sciences, České Budějovice; and the National Parasite Collection, USDA, Beltsville.

The diagnosis of the genus in this paper has been based on those of Freze (1965) and Schmidt (1986). All measurements (length by width) are given in millimeters unless otherwise stated. The specimens are deposited in the collection of the National Science Museum, Tokyo (NSMT).

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Class Cestoidea Rudolphi, 1808
Family Proteocephalidae La Rue, 1911
Genus *Proteocephalus* Weinland, 1858
***Proteocephalus fluviatilis* Bangham, 1925**
(Figs. 1–9)

Proteocephalus fluviatilis Bangham, 1925, pp. 258–261, figs. 8, 11, 13, 16, 18, 21 and 22.

Material examined. 1) Lot 1. Eighteen heat-killed mounted worms lacking some parts of their strobilae and several serially-sectioned proglottides (NSMT-Pl 3662) found in the intestine of *Micropterus salmoides* (Centrarchidae) provided by Hayashi from Lake Kizaki, Nagano Prefecture, on June 11, 1989.

2) Lot 2. Two flattened larval whole-mounts

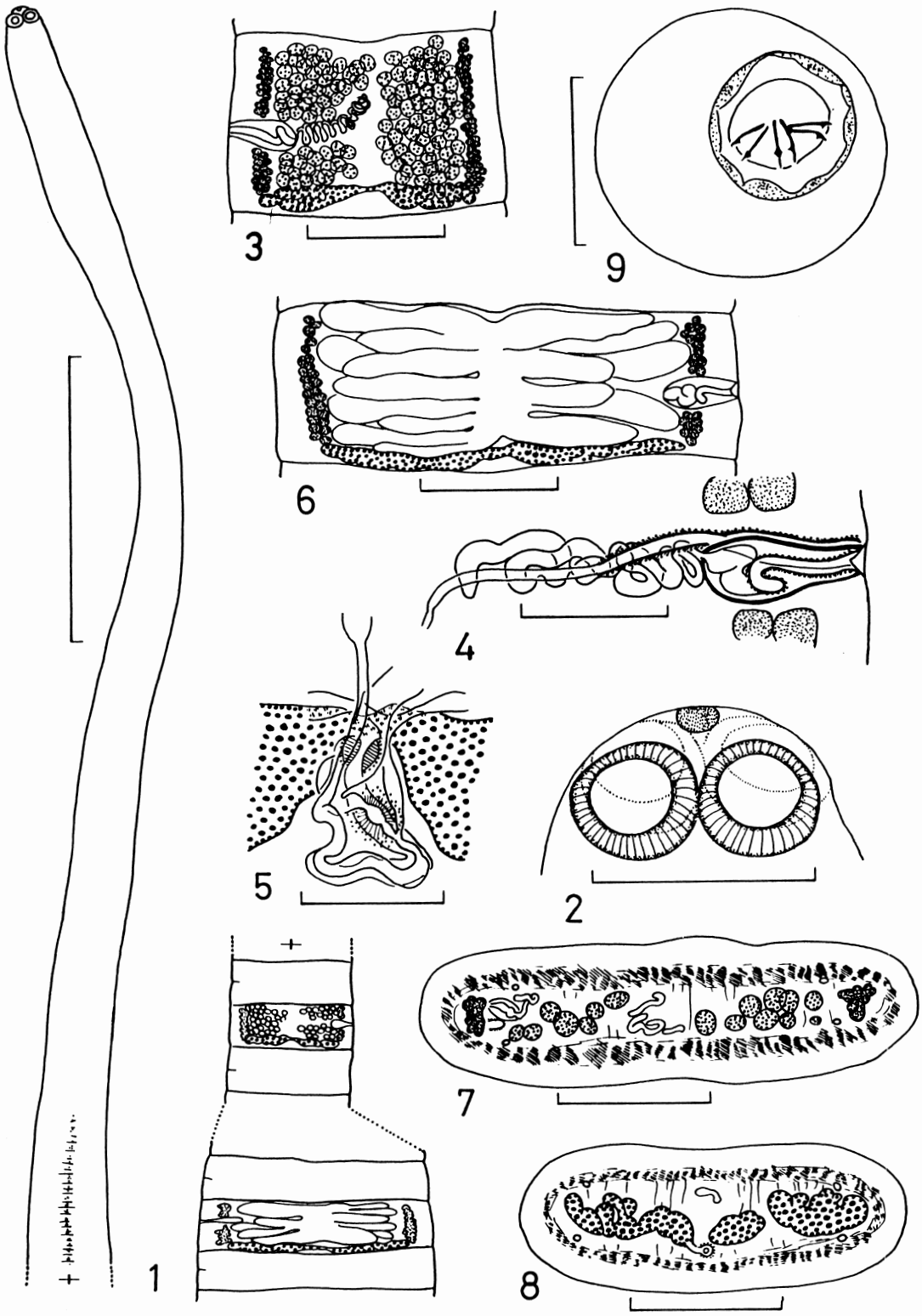
(NSMT-Pl 3663) found in the intestine of *M. salmoides* from Lake Kizaki on September 11, 1989.

Description. From lot 1; 10 worms measured (Figs. 1–9). Body much more than 200 long. Scolex 0.12–0.15 by 0.22–0.23. Suckers 0.09–0.11 by 0.09–0.12. Apical organ present, assuming a cellular mass without a cavity rather than a sucker with a cavity, surrounded by a thin membrane, 0.02–0.04 by 0.03–0.06. Neck long, slender, 6.30–10.08 long. Strobila slender, acraspedote, slightly indented at boundaries between proglottides, anapolytic. Proglottides up to 500 in number; immature ones much wider than long, narrower than others; mature ones wider than long, 0.22–0.50 by 0.76–1.26; gravid ones wider than long, 0.38–0.50 by 1.07–1.57. Inner longitudinal muscle sheath well developed. Ventral and dorsal osmoregulatory canals between testes and vitellaria.

Testes round, 0.03–0.06 in diameter, 60–96 per proglottis, lying in at least two frontal layers, absent along median line in some worms, almost preovarian, a few of them overlapping ovary posteriorly. Vas deferens forming a compact transverse or curved tangle of loops in poral half part of proglottis, storing sperm as an external seminal vesicle, lacking sperm in a short portion just before cirrus pouch. Cirrus pouch claviform, thick-walled, 0.16–0.22 by 0.06–0.08 and occupying 15–25% of proglottis width in mature proglottides. Internal seminal vesicle coiled usually once or rarely twice; ejaculatory duct a little longer than half length of cirrus pouch, curved posteriorly or not; cirrus short, probably aspinose. Genital atrium small. Genital pore about midlevel of proglottis. Genital papilla absent. Ovary transversely elongated, 0.66–1.01 by 0.06–0.07; each lobe multilobulate. Ootype complex behind ovarian isthmus. Vagina not ciliated internally, about twice as long as cirrus pouch, opening usually dorsal or rarely anterior to cirrus pore, running anterior to cirrus pouch, crossing external seminal vesicle ventrally; sphincter weakly developed; seminal receptacle slender, extending to near ovarian isthmus; seminal canal not very long. Uterus having 7–9 lateral diverticula on each side and 2–3 pores. External membrane of egg thin, globular, hyaline, 43–53 μm in diameter; middle membrane globular, thick, glanular, 25–29 μm in diameter; oncosphere 14–18 μm in diameter; hooks 8–9 (blade, about 3; rod, about 5–6) μm long. Vitelline bands preovarian.

Discussion. Proteocephalus fluviatilis was originally named from *M. dolomieui* taken in Ohio, U.S.A., by Bangham in 1925. I reexamined several of his voucher specimens (USNM. Helm. Coll. No. 60457). Differences can be seen in the apical organ, internal seminal vesicle and eggs between the present cestode and *P. fluviatilis* of Bangham (1925) and Fischer (1968) from North America. Bangham described that the apical organ (= fifth sucker in his paper) appears to be functional and has a shallow cup and musculature quite similar to the suckers. According to Fischer, however, it (= rostellum in his paper) is always a solid structure that never assumes the cup-like appearance of the suckers and quite unlikely to function as a sucker. In both Bangham's and the present specimens, it appeared a cellular mass without a cavity. The present specimens had the internal seminal vesicle making usually one or rarely two convolutions. Bangham described the organ (= ductus ejaculatorius in his paper) as coiled twice or three times, which has been confirmed in his specimens. The measurements of living eggs given by Fischer are: external membrane, 57 to 95 μm in diameter; middle membrane, 27 by 27 to 38 by 31 μm; oncosphere, 17 by 17 to 25 by 22 μm; and embryonic hooks, 6 to 10 μm long. They are a little larger than those of the present formalin-preserved eggs. The differences seem to be so slight that the present cestode is practically indistinguishable from *P. fluviatilis*. Consequently I identify it as *P. fluviatilis*.

If the above identification is correct, this is the first published record of *P. fluviatilis* from Japan. The species must have recently been introduced from North America into Japan by accident. Probably some infected individuals of *M. salmoides*, which also serves as a final host for the species in North America (Freze, 1965), some time carried ancestors of the Japanese form of the species in them from North America to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Japan. So may have done *Lepomis macrochirus* (Centrarchidae). It is said that juveniles of *M. salmoides* and *L. macrochirus* have been brought from the U.S.A. into Japan a few times since 1925 and 1960, respectively. There is also the possibility that the water of the fish tanks used for transporting the fish in them may have included live cestode eggs or copepods harboring infective cestode larvae. It is likely that the cestode has been enlarging its distribution range in Japan through artificial transplantation of its host fish.

Proteocephalus midoriensis sp. n.
(Figs. 10–18)

Material examined. Several immature flattened whole-mounts, 12 heat-killed and 12 flattened gravid whole-mounts and several serially-sectioned worms (NSMT-Pl 3642 and 3652–3661) found in the intestine of *Lefua echigonia* (Homalopteridae) from Midori, Iiyama City, Nagano Prefecture, from November 1982 to November 1990.

Description. Eight gravid worms (NSMT-Pl 3658, fixed in hot AFA) measured (Figs. 10–18). Body up to 22 long. Scolex globular, 0.14–0.16 by 0.25–0.28. Suckers 0.11–0.14 by 0.14–0.16. Apical organ absent. Neck usually narrower than scolex, fairly long, 0.69–1.57 long. Strobila slender, acraspedote, indented at boundaries between proglottides, anapolytic. Proglottides up to 60 in number; immature ones much wider than long, narrower than others; mature ones usually longer than wide, 0.57–1.20 by 0.69–1.13; gravid ones usually longer than wide, 0.82–1.57 by 0.69–1.04. Inner longitudinal muscle sheath weakly developed. Ventral and dorsal osmoregulatory canals ventral and dorsal to vitellaria.

Testes round, 0.03–0.11 in diameter, 62–123 per proglottis, lying in at least two frontal layers, preovarian. Vas deferens compactly convoluted in poral half part of proglottis, storing sperm as an external seminal vesicle, lacking sperm in a very short portion just before cirrus pouch. Cirrus pouch club-shaped, rather thick-walled, 0.14–0.22 by 0.06–0.07 and occupying 20–27% of proglottis width in mature proglottides. Internal seminal vesicle S-shaped; ejaculatory duct two-thirds as long as cirrus pouch, straight; cirrus short, aspinose. Genital atrium small. Genital pore lying between anterior third and middle of proglottis. Genital papilla absent. Ovary 0.44–0.69 by 0.11–0.22; each lobe with several transverse branches rather than lobules. Ootype complex behind ovarian isthmus. Vagina not ciliated internally, about twice as long as cirrus pouch, opening anterior to cirrus pore, running anterior to cirrus pouch, crossing external seminal vesicle ventrally; sphincter poorly developed; seminal receptacle long, thick, sinuous, reaching ovarian isthmus; seminal canal long, looped. Uterus having 12–17 lateral diverticula on each side and 3–4 pores. External membrane of egg globular, thin, hyaline, 48–72 μm in diameter; middle membrane globular, thick, granular, 26–29 μm in diameter; oncosphere 21–22 μm in diameter; hooks about 8 (blade, about 3; rod, about 5) μm long. Vitelline bands preovarian.

Type host: *Lefua echigonia* (Homalopteridae).

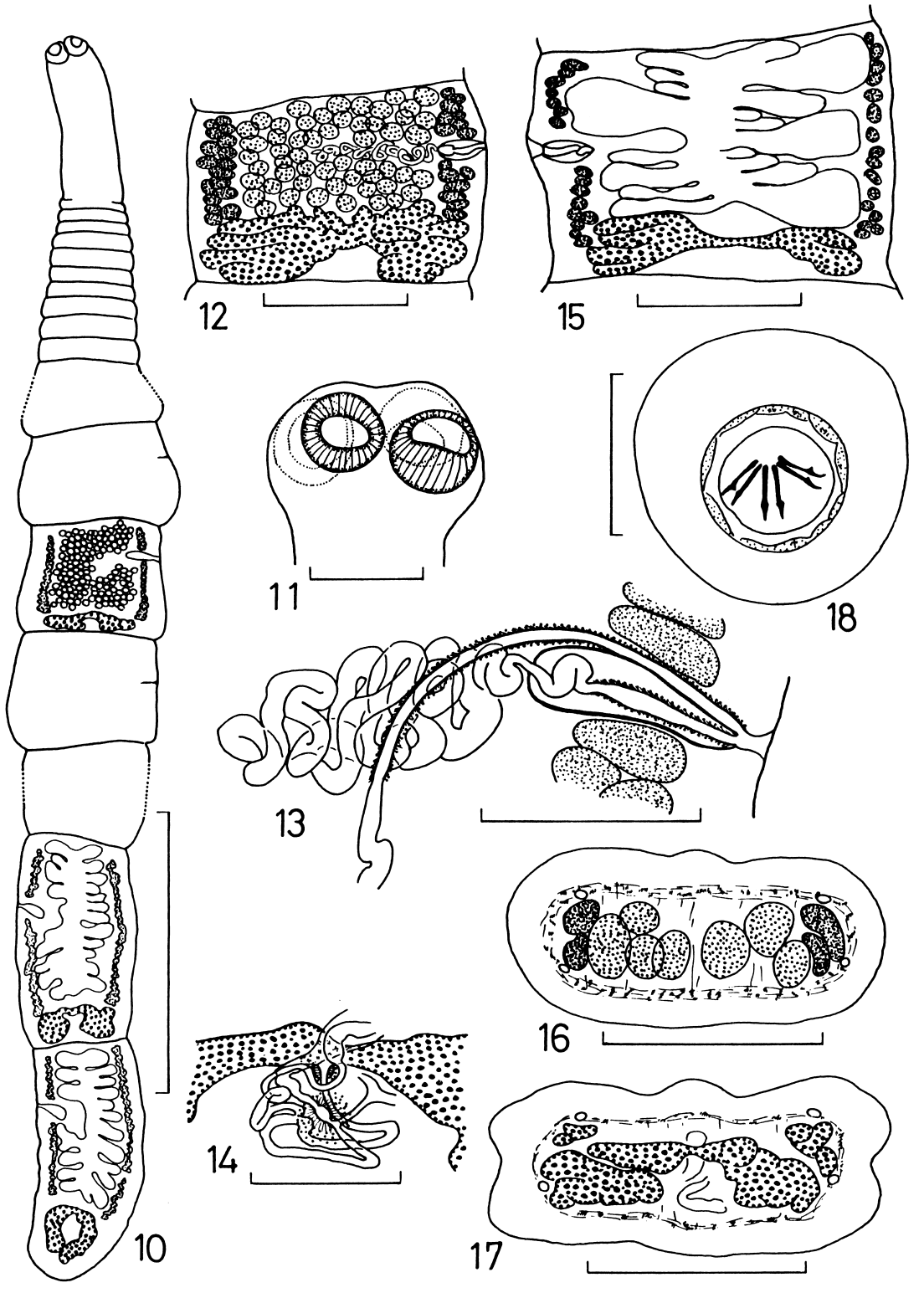
Site of infection: Intestine.

Type locality: Midori, Iiyama City, Nagano Prefecture.

Specimens: Holotype, NSMT-P1 3658; paratypes, NSMT-P1 3642 and 3652–3661.

Discussion. This new species, *Proteocephalus midoriensis* sp. n., appears most closely similar to *P. sagittus* (Grimm, 1872) La Rue, 1911. However it differs from the latter (Freze, 1965; Scholz, 1989) in a smaller scolex, more testes arranged in at least two frontal layers, a less convoluted internal seminal vesicle, a smaller cirrus pouch, rather branched ovarian lobes, a much more weakly developed vaginal sphincter, a longer and more sinuous seminal receptacle, more

Figs. 1–9. *Proteocephalus fluviatilis* Bangham, 1925 (lot 1), from *Micropterus salmoides*. 1: Gravid worm. 2: Anterior part of scolex. 3: Mature proglottis, ventral view. 4: Terminal genitalia, ventral view. 5: Ootype complex, dorsal view. 6: Gravid proglottis, ventral view. 7: Transverse section of mature proglottis, showing testes and vitelline follicles. 8: Transverse section of mature proglottis, showing ovary. 9: Egg.
(Scale bars: 2 mm in Fig. 1; 0.4 mm in Figs. 3 and 6–8; 0.2 mm in Figs. 2, 4 and 5; 0.03 mm in Fig. 9.)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uterine pouches and larger eggs.

Protocephalus parasiluri Yamaguti, 1934

Proteocephalus parasiluri Yamaguti, 1934, pp. 42–44, figs. 67–72.

Material examined. 1) Lot 1. Whole-mounted larval holotype, and paratypes (1 whole-mounted larva, and whole-mounted and serially-sectioned fragments of 1 mature strobila) (MPM Coll. No. 22617) of *P. parasiluri* of Yamaguti (1934) found in the intestine of *Parasilurus asotus* [= *Silurus asotus*] (Siluridae) from Lake Ogura, Kyoto Prefecture, on [November 9 and 14, 1931, and February 9, 1932].

2) Lot 2. Three whole-mounted larvae (MPM Coll. Nos. 22618 and 22619) of *Proteocephalus* larvae of Yamaguti found in the rectum of *Chaenogobius urotaenia* (Gobiidae) on October 11, 1931, and in the intestine of *Odontobutis obscura* (Gobiidae) on June 9, 1932, both from Lake Ogura.

Discussion. Lots 1 and 2 are stained poor. The holotype is a larva, and the mature paratype is fragmentary without the scolex. It seems from my reexamination that Yamaguti (1934) fully and adequately described and figured this species from lot 1. He claimed to find larvae of the species in the large intestine [= rectum] of *Mogurnda obscura* [= *Odontobutis obscura*] from Lake Ogura on May 14, 1928, and the small intestine of *Gnathopogon elongatus* (Cyprinidae) from Lake Biwa, on March 13, 1932. Probably he gave mistaken data for this record (see lot 2).

The species needs redescription from new entire, ripe specimens. Nagasawa (personal communication) found it in *S. asotus* from Lake Biwa in November 1980, but unfortunately his material has already been lost.

Proteocephalus plecoglossi Yamaguti, 1934 (Figs. 19–25)

Proteocephalus sp. of Kataoka, 1930, pp. 491–492, figs. 1–4, 1 table.

Proteocephalus neglectus La Rue, 1911, sensu Kataoka and Momma, 1932, pp. 129–132, figs. 1–2, 2 tables; 1933, pp. 15–20, figs. 1–4, 1 table.

Proteocephalus plecoglossi Yamaguti, 1934, pp. 44–46, figs. 73–76.

Material examined. 1) Lot 1. Whole-mounted mature holotype, and paratypes (1 mature whole-mount, and whole-mounted and serially-sectioned gravid proglottides) (MPM Coll. No. 22620) of *P. plecoglossi* of Yamaguti (1934) found in the [pyloric ceca and] intestine of *Plecoglossus altivelis* (Plecoglossidae) from Lake Biwa, Shiga Prefecture, on March 23, 1928.

2) Lot 2. Eleven juvenile whole-mounts (unpublished; MPM Coll. Nos. 2058 and 2059) of *P. neglectus* of Dr. Nobutaro Ishii found in *Pl. altivelis* (other data not given).

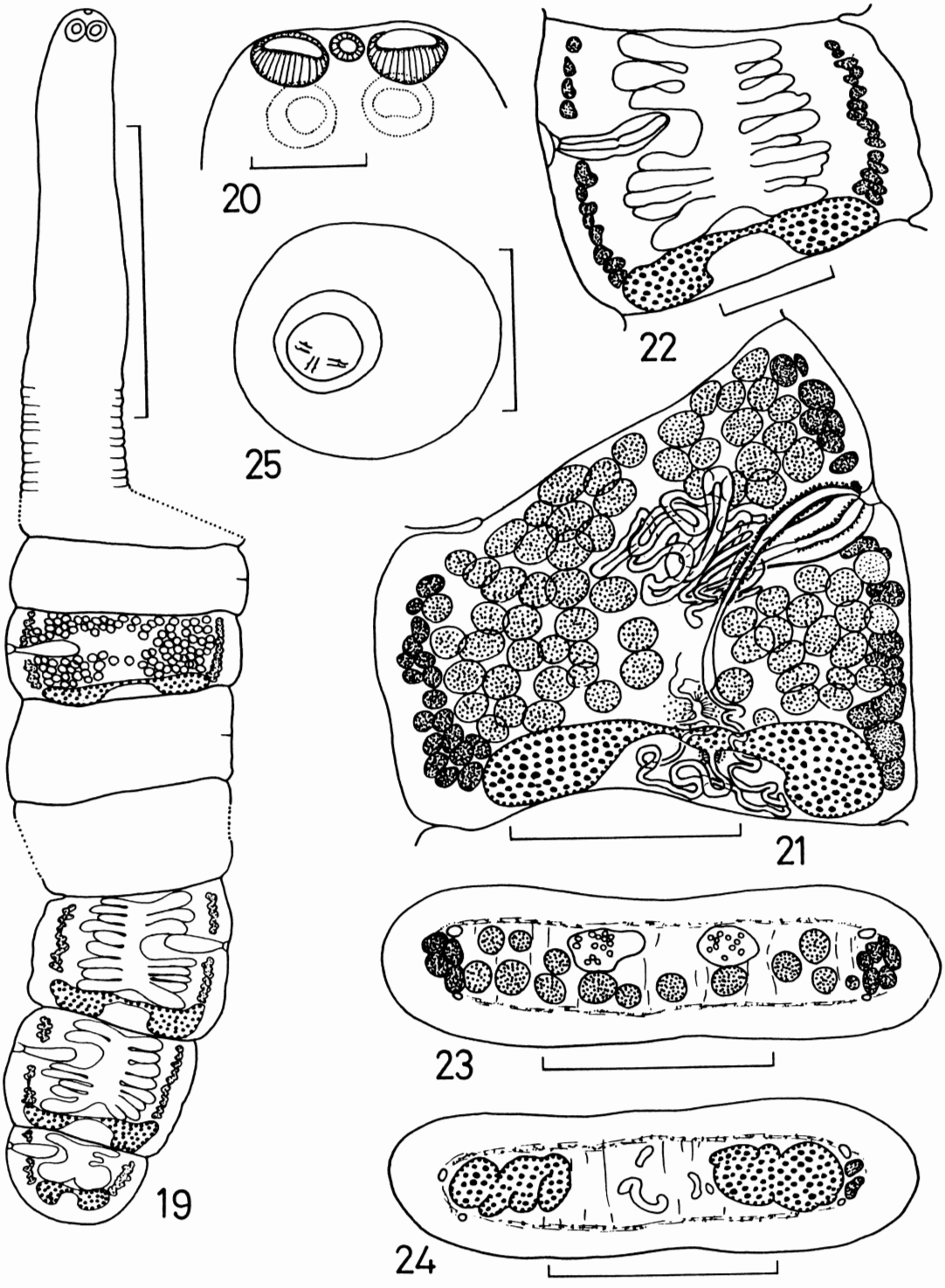
3) Lot 3. One gravid, 4 mature and 2 immature flattened whole-mounts (unidentified and unpublished; MPM Coll. No. 30025) of Dr. Yoshimasa Ozaki found in *Pl. altivelis* from Lake Biwa (other data not given).

4) Lot 4. Four gravid and 7 mature heat-killed whole-mounts (NSMT-Pl 3641) found in the intestine of *Pl. altivelis* provided by Ohmae and Sasaki from Lake Biwa in May 1989.

Description. 1) For the original description and figures for lot 1, see Yamaguti (1934).

2) From lots 1 and 3–5; 11 specimens of lot 4 fixed in hot AFA measured (Figs. 19–24). Body 22 long in the largest gravid worm with about 55 proglottides. Scolex 0.16–0.25 by 0.38–0.57. Suckers 0.11–0.16 by 0.13–0.17. Apical sucker present, 0.03–0.04 by 0.04–0.07. Neck long, slender, 3.15–6.30 long. Strobila slender, acraspedote, indented at boundaries between proglottides, anapolytic. Proglottides up to 110 in number; immature ones much wider than long, narrower than others; mature ones usually wider than long, 0.31–0.88 by 0.60–0.98; gravid ones usually wider than long,

Figs. 10–18. *Proteocephalus midoriensis* sp. n. (holotype and paratypes) from *Lefua echigonia*. 10: Gravid worm, holotype, heat-killed. 11: Anterior part of scolex. 12: Mature proglottis, ventral view. 13: Terminal genitalia, dorsal view. 14: Ootype complex, dorsal view. 15. Gravid proglottis, ventral view. 16: Transverse section of mature proglottis, showing testes and vitelline follicles. 17: Transverse section of mature proglottis, showing ovary. 18: Egg. (Scale bars: 2 mm in Fig. 10; 0.4 mm in Figs. 12 and 15; 0.2 mm in Figs. 11, 13, 14, 16 and 17; 0.03 mm in Fig. 18.)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0.63–0.85 by 0.63–1.16. Inner longitudinal muscle sheath poorly developed. Ventral and dorsal osmoregulatory canals ventral and dorsal to vitellaria.

Testes elliptical, 0.06–0.07 by 0.04–0.09, 65–113 per proglottis, lying in at least two frontal layers, almost preovarian, a few of them overlapping ovary posteriorly. Vas deferens long, convoluted compactly in poral half part of proglottis, sometimes invading the other half part, storing sperm as an external seminal vesicle, lacking sperm in a short portion just before cirrus pouch. Cirrus pouch clavate, thick-walled, thinner in distal fourth part, 0.23–0.31 by 0.06–0.09 and occupying 32–45% of proglottis width in mature proglottides. Internal seminal vesicle slightly sinuous or straight; ejaculatory duct half as long as cirrus pouch, slightly winding or straight; cirrus short, aspinose. Genital atrium small. Genital pore lying between anterior one-quarter and middle of proglottis. Genital papilla absent. Ovary 0.44–0.69 by 0.09–0.18; each lobe almost elliptical, smooth or indented. Ootype complex usually posterior or rarely dorsal or anterior to ovarian isthmus. Vagina not ciliated internally, a little longer than cirrus pouch, opening in front of cirrus pore, running anterior to cirrus pouch and crossing it ventrally; sphincter well developed, small, surrounding opening of vagina; seminal receptacle short, slender or expanded, extending to some distance anterior to ovarian isthmus; seminal canal long, looped. Uterus having 6–11 lateral diverticula on each side and at least 1 pore. Embryonic hooks 8–10 (blade, 3–4; rod 5–6) μm long. Vitelline bands preovarian.

Discussion. This study proposes a slight emendation of Yamaguti's (1934) original description for *P. plecoglossi* as follows: testes numbering 65 to 113 per proglottis, arranged in at least two frontal layers; cirrus pouch extending 32 to 45% of proglottis width in mature proglottides; vagina opening in front of cirrus pore, with a well-developed, small sphincter around its opening; uterus possessing 6 to 11 lateral pouches on either side and at least one pore; and embryonic hooks 8 to 10 μm long. According to Kataoka and Momma (1932, 1933), live eggs are: external membrane, 0.087 to 0.110 by 0.09 to 0.137 mm; middle membrane, 0.030 to 0.033 mm in diameter; oncosphere, 0.013 to 0.023 mm in diameter. Since good fully-embryonated eggs were not available in this study, the figure of the egg by Kataoka and Momma (1934, fig. 1) is reproduced here (Fig. 25).

Kataoka and Momma (1932, 1933) and Yamaguti (1934) compared this cestode only with *P. neglectus* that La Rue (1911, 1914) described and figured on the basis of some pieces of ripe strobila(e) without the heads. Kataoka and Momma said that it is almost impossible to separate the cestode from *P. neglectus*. Yamaguti stated, however, that the cestode is different from *P. neglectus* in "the absence of the genital papilla, the coiled ductus ejaculatorius, the size of the cirrus pouch and onchosphere, the position of the sphincter vaginae, etc." According to Yamaguti and La Rue, the genital papilla (= prominence in La Rue) in absent in *P. plecoglossi,* and present and slight in *P. neglectus*; the ductus ejaculatorius (= internal seminal vesicle in this paper) is coiled once or twice in *P. plecoglossi,* and straight in *P. neglectus*; the cirrus pouch is 0.15 to 0.2 mm long, extending one-third or a little less across the proglottis width in *P. plecoglossi,* and 0.185 to 0.265 mm long by 0.080 mm wide in contracted condition and 0.340 mm long in normal condition, extending one-fourth to one-third across the proglottis width in *P. neglectus*; the oncosphere is about 0.016 mm in diameter in sections in *P. plecoglossi,* and 0.026 to 0.0265 mm in diameter in *P. neglectus*; the sphincter vaginae is around the vaginal opening in both. Thus the differential criteria pointed out by Yamaguti for *P. plecoglossi* are unclear. Recently Freze (1965), Moravec (1982), Priemer (1982) and Scholz

Figs. 19–25. *Proteocephalus plecoglossi* Yamaguti, 1934, from *Plecoglossus altivelis*. 19: Gravid worm (lot 3). 20: Anterior part of scolex (lot 3). 21: Mature proglottis (lot 4), ventral view. 22: Gravid proglottis (lot 3), ventral view. 23: Transverse section of almost gravid proglottis (lot 1), showing testes and vitelline follicles. 24: Transverse section of mature proglottis (lot 1), showing ovary. 25: Egg, redrawn from Kataoka and Momma (1934). (Scale bars: 2 mm in Fig. 19; 0.4 mm in Figs. 21–24; 0.05 mm in Fig. 25.)

(1989) described and figured *P. neglectus* from their own specimens with the heads. I was able to reexamine several of Scholz's mounted Czechoslovak specimens (No. Coll. C-31). They agreed well with his description and figures except that a long slender neck was present; the vagina was a little longer than the cirrus pouch and crossed it or the external seminal vesicle ventrally; the uterus had two or three pores; and the embryonic hooks measured 11 to 12 (blade, 3 to 4: rod, 8 to 9) μm long. The present cestode certainly resembles *P. neglectus* but seems to me distinguishable from it by more testes, more uterine pouches, fewer uterine pores, and larger eggs with smaller oncospheres and smaller embryonic hooks. The presence or absence of the genital papilla is not constant in *P. neglectus*. Further the two cestodes are considered to differ in host fish species and geographical distribution as well: the present cestode parasitizes *Pl. altivelis* (Plecoglossidae) in Lake Biwa, Japan; but *P. neglectus, Salmo trutta* m. *fario, S. gairdneri* [= *Oncorhynchus mykiss*] and *S. ischchan* (Salmonidae) and *Cobitis taenia* (Cobitidae) in Europe.

The cestode also appears to resemble *P. percae* (Müller, 1780) Railliet, 1899, and *P. longicollis* (Zeder, 1800) Nufer, 1905. *P. percae* is fundamentally a parasite of *Perca fluviatilis* (Percidae) on the Eurasian Continent and much larger, measuring up to 100 mm in body length, with a larger, well-developed apical sucker being about half as large as the four suckers and smaller eggs (Freze, 1965; Priemer, 1982; Scholz, 1989). The diameter of the apical sucker is less than one-third of that of the suckers in the present cestode. Von Linstow (1891) and Willemse (1965, 1969) described *Taenia longicollis* Rudolphi, 1810, or *P. longicollis* on the basis of their own specimens found in *Salmo Eperlanus* = *Osmerus eperlanus* from Europe. Their descriptions seem to agree well with each other, and therefore they should be adopted for *P. longicollis* if von Linstow's *T. longicollis* is identical with Rudolphi's (1810) *T. longicollis* (see La Rue, 1914). Freze presented a description for *P. longicollis* from his own material and Dubinina's (1962) description of the species. Their specimens were taken from *O. eperlanus* of Kamchatka and the basin of the Baltic Sea. When compared with the descriptions by von Linstow and Willemse, they have so wide morphological variations in some taxonomically important features such as the size of the apical sucker, the number of the testes and the number of the uterine pouches. The strobila broadens markedly beyond the neck section, reaching the maximum width immediately; the testes are 75 to 155 in number and arranged in two layers; and the uterus has five to eight pouches on each side. Their specimens may have been composed of at least two different species, probably *P. longicollis* and *P. tetrastomus* (Rudolphi, 1810) Willemse, 1965, the latter of which also parasitizes *O. eperlanus* (see below). The present cestode can be readily separated from *P. longicollis* of von Linstow and Willemse by a smaller apical sucker, much more testes and more uterine pouches. Iwata (1938) stated that the cestode is more closely similar to *P. fallax* La Rue, 1911, than to *P. neglectus* and *P. percae* though he thought the latter three synonyms. However the cestode can be distinguished from *P. fallax* (La Rue, 1914) by larger suckers, more testes, more uterine pouches and smaller oncospheres. Consequently I prefer to retain *P. plecoglossi* as a valid species.

Nagasawa (personal communication) found adults of the species in *Pl. altivelis,* and larvae in *Chaenogobius isaza* (NSMT-Pl 3643), *C. urotaenia, Rhinogobius brunneus* (NSMT-Pl 3644) (Gobiidae), *Cottus reinii* (Cottidae), *Hemibarbus harbus, Ischikauia steenackeri, Opsariichthys uncirostris, Tribolodon hakonensis* (Cyprinidae), *Oncorhynchus masou rhodurus* (Salmonidae), *Silurus biwaensis* and *S. lithophilus* (Siluridae) all from Lake Biwa in May 1979 and February and November 1980. All of his specimens except those with the above-mentioned specimen numbers have already been lost.

Proteocephalus tetrastomus (Rudolphi, 1810) Willemse, 1965

(Figs. 26–34)

Scolex tetrastomus Rudolphi, 1810, pp. 6–7.

Proteocephalus tetrastomus: Willemse, 1965, p. 66, figs. 4 and 11, tables 16 and 18; 1969, pp. 208–210,

figs. 1–2.

Material examined. 1) Lot 1. Twenty-one gravid whole-mounts (NSMT-Pl 3645 and 3646) found in the intestine of formalin-preserved *Hypomesus nipponensis* (Osmeridae) taken by Utoh and Yamagishi in Lake Abashiri, Hokkaido, on August 25, 1981, and July 12, 1989.

2) Lot 2. Seven gravid and 44 immature flattened whole-mounts (NSMT-Pl 3647) found in the intestine of *H. nipponensis* from Lake Abashiri on July 20, 1984.

3) Lot 3. Thirty heat-killed and 14 flattened gravid whole-mounts and several serially-sectioned gravid worms (NSMT-Pl 3648 and 3649) found in the intestine of *H. nipponensis* from Lake Suwa, Nagano Prefecture, on December 19, 1983, and May 12, 1989.

4) Lot 4. Eight gravid and 11 immature flattened whole-mounts (NSMT-Pl 3650) found by Uchida in the intestine of *H. nipponensis* from Lake Ashinoko, Kanagawa Prefecture, on July 12, 1989.

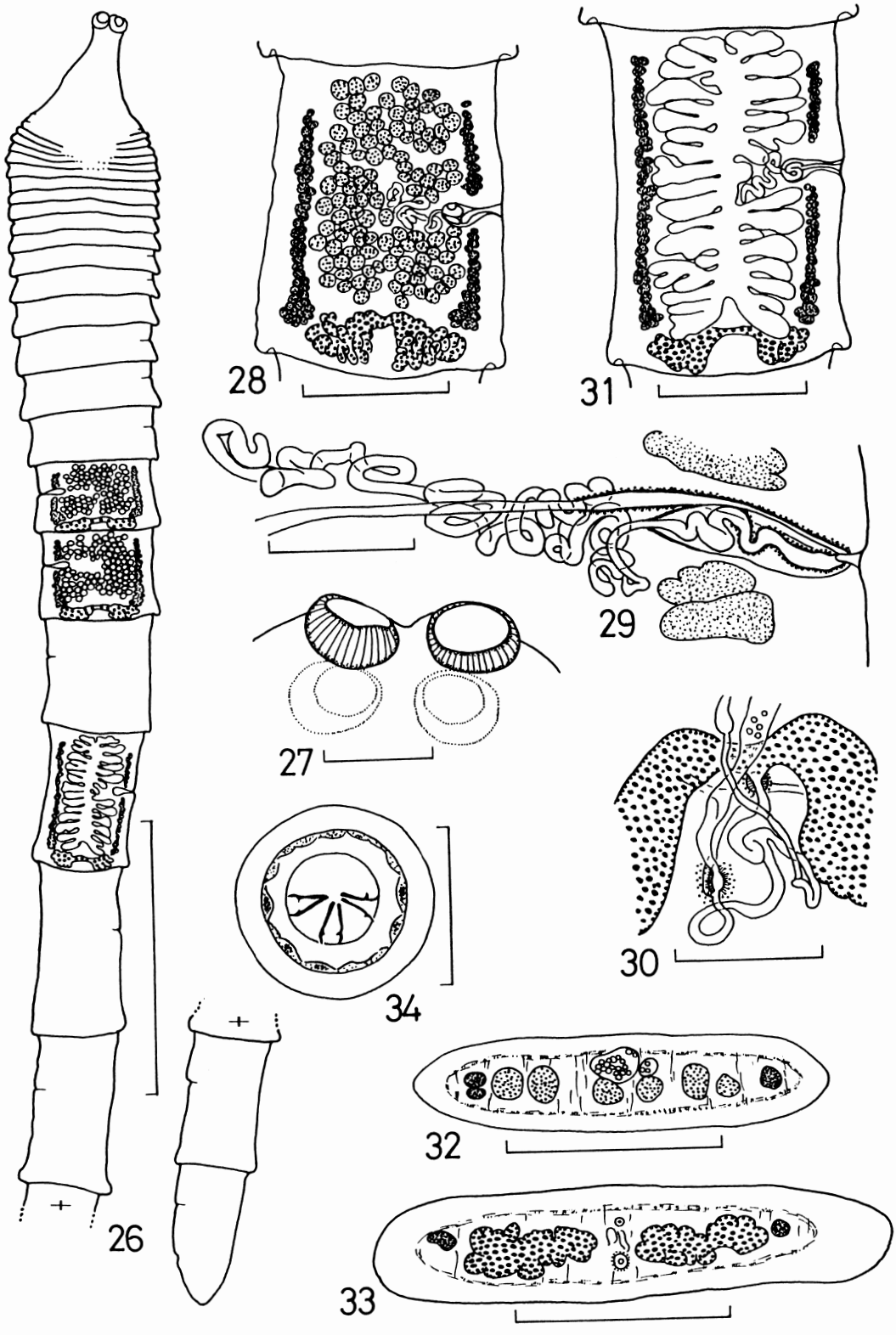
5) Lot 5. One flattened gravid whole-mount (NSMT-Pl 3651) found by Nagasawa in the intestine of *Salvelinus leucomaenis* (Salmonidae) from Lake Toro near Kushiro, Hokkaido, on May 15, 1981. (This slide also contains a caryophyllidean and a *Eubothrium* cestode.)

Description. From lot 3; 10 worms fixed in hot AFA (NSMT-Pl 3649) measured (Figs. 26–34). Body up to 18 long (48 long in lot 1, NSMT-Pl 3648, fixed in hot formalin). Scolex 0.09–0.13 by 0.23–0.35. Suckers 0.09–0.13 by 0.10–0.13. Apical organ absent. Neck short, deltoid, 0.47–1.01 long. Strobila elongate-spathulate, craspedote, anapolytic. Proglottides about 35 in number; immature ones much wider than long, much wider than others; mature ones slightly wider than long, 0.50–0.82 by 0.69–0.85; gravid ones longer than wide, 0.76–1.13 by 0.63–0.69. Inner longitudinal muscle sheath poorly developed. Ventral and dorsal osmoregulatory canals between testes and vitellaria.

Testes round, 0.03–0.06 in diameter, 58–112 per proglottis, lying in a single frontal layer, preovarian. Vas deferens forming a compact transverse tangle of loops in poral half part of proglottis, storing sperm as an external seminal vesicle, lacking sperm in a short portion just before cirrus pouch. Cirrus pouch spindle-shaped, thin-walled, a little thicker in proximal third part than in others, 0.14–0.19 by 0.05–0.06 and occupying 20–25% of proglottis width in mature proglottides. Internal seminal vesicle curled about twice; ejaculatory duct extending two-thirds as long as cirrus pouch, slightly winding; cirrus short, aspinose. Genital atrium small. Genital pore lying between anterior third and middle of proglottis. Genital papilla absent. Ovary 0.50–0.63 by 0.11–0.16; each lobe multilobulate. Ootype complex behind ovarian isthmus. Vagina not ciliated internally, a little longer than cirrus pouch, opening usually dorsal or rarely anterior to cirrus pore, lying anterior to cirrus pouch, crossing external seminal vesicle ventrally; sphincter weakly developed; seminal receptacle slender, extending to near ovarian isthmus; seminal canal not very long, looped or not. Uterus having 9–16 lateral diverticula on each side and 2–3 pores. External membrane of egg globular, thin, hyaline, 35–42 μm in diameter; middle membrane globular, thick, granular, 24–27 μm in diameter; oncosphere 14–19 μm in diameter; hooks about 7 (blade, about 2; rod, about 5) μm long. Vitelline bands preovarian.

Discussion. Willemse (1965) studied the morphology and life cycle of a cestode which he found in *Osmerus eperlanus* (Osmeridae) of the Netherlands. He regarded the cestode as *Scolex tetrastomus* Rudolphi, 1810, and, as far as I know, he was the first to use the combination *Proteocephalus tetrastomus* (Rudolphi, 1810).

This Japanese cestode closely resembles *P. tetrastomus* as described by Willemse (1965, 1969) in all important features except in the size of the suckers, the number of the testes, the position of the vaginal pore, and the number of the uterine pouches. Reexamination of several whole-mounts (v.Pl.310.1 and 4–7) from Willemse's Dutch material has shown that the suckers are 0.12 to 0.19 mm in diameter, the testes are 58 to 114 per proglottis, the vagina opens anterior or dorsal to the cirrus pore, and the uterus has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8 to 11 lateral diverticula on either side. Therefore I conclude that the present cestode is identical with Willemse's *P. tetrastomus*. This is the first published record of the species from Japan.

Other Previous Records of *Proteocephalus* from Japan

1) Fukui (1958, 1961) claimed to obtain *Proteocephalus* larvae from *Oncorhynchus keta* and *O. nerka* (Salmonidae) caught in the northern North Pacific Ocean and Bering Sea in 1956. His identification of the larvae is questionable on account of the long marine life of their host fish. He also described and figured a *Proteocephalus* larva which he found in the intestine of *O. gorbuscha* from Yubetsu, Hokkaido, on September 2, 1958. This larva was 1.5 mm in body length with four suckers and a large, well-formed apical sucker being over half the suckers in diameter. His specimens need reexamination, but most presumably they have already been lost.

2) Sorimachi *et al.* (1984) identified cestode larvae as *Proteocephalus* sp. which they found in the pyloric ceca and intestine of catadromous amago salmon, *O. masou macrostomus,* caught in the Nagara River, Gifu Prefecture, in May 1980 and 1981. I consider, however, that their cestode belongs to some marine genus other than the genus *Proteocephalus* because it is evident from their notes that the amago salmon examined had received infection with the larvae while still having been staying in the sea.

Acknowledgment

I am grateful to the following persons: Dr. Hidetake Hayashi, Shinshu University, Matsumoto, Messers. Hiromi Ohmae and Haruo Sasaki, Nagano Fisheries Experimental Station, Suwa and Saku, respectively, and Dr. Hitoshi Utoh and Mr. Yoshihiro Yamagishi, Hokkaido Fisheries Experimental Station, Abashiri, for the fish examined; Dr. Kazuya Nagasawa, Hokkaido Fisheries Experimental Station, Yoichi, and Dr. Akihiko Uchida, Azabu University, Sagamihara, for the specimens studied; Mr. Shunya Kamegai, MPM, Tokyo, Dr. S. van der Spoel, Institute of Taxonomic Zoology (Zoölogisch Museum), University of Amsterdam, Amsterdam, the Netherlands, Dr. F. Moravec, Institute of Parasitology, Czechoslovak Academy of Science, České Budějovice, Czechoslovakia, and Dr. J. Ralph Lichtenfels, Biosystematic Parasitology Laboratory, Beltsville, U.S.A., for the loan of the specimens; and Dr. Kengo Ishino, Hokkaido Fisheries Experimental Station, Abashiri, Dr. Teiji Kifune, University of Fukuoka, Fukuoka, Dr. J. J. Willemse, Amsterdam, the Netherlands, and Dr. J. C. Pearson, University of Queensland, St. Lucia, Australia, for their interest and help.

References

1) Bangham, R. V. (1925): A study of the cestode parasites of the black bass in Ohio, with special reference to their life history and distribution. Ohio J. Sci., 25, 255–270.
2) Dubinina, M. N. (1962): Class Cestoidea Rud., 1808 Tapeworms. In Key to Parasites of Freshwater Fish of the U.S.S.R., Pavlovskii, E. N., ed., Izdatel'stvo AN SSSR, Moskva, 384–438. English translation by Birron, A. and Cole, Z. S., 1964, IPST Cat. No. 1136, 445–510.
3) Fischer, H. (1968): The life cycle of *Proteocephalus fluviatilis* Bangham (Cestoda) from smallmouth bass, *Micropterus dolomieui* Lacépède. Can. J. Zool., 46, 569–579.
4) Freze, V. I. (1965): Proteocephalata in Fish, Amphibians, and Reptiles. Essentials of Cestodology, Vol. 5, Skrjabin, K. I., ed., Izdatel'stvo "Nauka", Moskva, 538 pp. English translation by Berick, R. and Birron, A., 1969, IPST Cat. No. 1853, 597 pp.
5) Fukui, T. (1958): [Parasites of salmonoid fishes (part 1).] Bull. Yokohama Munic. Univ., Nat. Sci. Ser., 10, 581–634. (in Japanese)
6) Fukui, T. (1961): [Parasites of salmonoid fishes (part 2).] Bull. Yokohama Munic. Univ., Nat. Sci. Ser., 12, 82–147. (in Japanese)
7) Iwata, S. (1938): Notes on the specific name of a parasitic cestode in *Plecoglossus altivelis* of Lake Biwa. Rikusuigaku Zasshi (Jpn. J. Limnol.), 8, 463–472. (in Japanese with English title)
8) Kataoka, N. (1930): [On a cestode parasitic in

Figs. 26–34. *Proteocephalus tetrastomus* (Rudolphi, 1810) Willemse, 1965 (lot 3), from *Hypomesus nipponensis*. 26: Gravid worm. 27: Anterior part of scolex. 28: Mature proglottis, ventral view. 29: Terminal genitalia, ventral view. 30: Ootype complex, dorsal view. 31: Gravid proglottis, ventral view. 32: Transverse section of fully mature proglottis, showing testes and vitelline follicles. 33: Transverse section of mature proglottis, showing ovary and vitelline follicles. 34: Egg.
(Scale bars: 2 mm in Fig. 26; 0.4 mm in Figs. 28 and 31–33; 0.2 mm in Figs. 27, 29 and 30; 0.03 mm in Fig. 34.)

Plecoglossus altivelis (a preliminary note).] Dobutsugaku Zasshi (Zool. Mag.), 42, 490–492. (in Japanese)

9) Kataoka, N. and Momma, K. (1932): [On a cestode parasitic in *Plecoglossus altivelis*.] Dobutsugaku Zasshi (Zool. Mag.), 44, 127–136. (in Japanese)

10) Kataoka, N. and Momma, K. (1933): A cestode parasitic in *Plecoglossus altivelis*. Annot. Zool. Japon., 14, 13–22.

11) Kataoka, N. and Momma, K. (1934): A preliminary note on the life-history of *Proteocephalus neglectus*, with special reference to its intermediate host. Jpn. J. Sci. Fish., 3, 125–126.

12) La Rue, G. R. (1911): A revision of the cestode family Proteocephalidae. Zool. Anz., 38, 473–482.

13) La Rue, G. R. (1914): A revision of the cestode family Proteocephalidae. Ill. Biol. Monogr., 1, 1–350.

14) Linstow, O. F. B. von (1891): Ueber den Bau und die Entwicklung von *Taenia longicollis* Rud. Ein Beitrag zur Kenntniss der Fischtänien. Jena. Z. Naturw., 25, 565–576, pl. 25.

15) Moravec, F. (1982): The finding of the cestode *Proteocephalus neglectus* La Rue, 1911 from brown trout from Czechoslovakia. Folia Parasitol., 29, 189–190.

16) Priemer, J. (1982): Bestimmung von Fischbandwürmern der Gattung *Proteocephalus* (Cestoda; Proteocephalidea) in Mitteleuropa. Zool. Anz., 208, 244–264.

17) Rudolphi, C. A. (1810): Entozoorum sivi Vermium Intestinalium Historia Naturalis. Vol. 2 (2), Amstelaedami, xii + 386 pp.

18) Schmidt, G. D. (1986): CRC Handbook of Tapeworm Identification. CRC Press, Inc., Boca Raton, Florida, 675 pp.

19) Scholz, T. (1989): Amphilinida and Cestoda, parasites of fish in Czechoslovakia. Acta Sci. Nat. Brno, 23, 1–56.

20) Sorimachi, M., Sako, H. and Ishida, N. (1984): [Survey of pathogens of masu salmon and amago salmon in rivers. 4. Catadromous amago salmon.] In [General Studies on the Development of the Domesticating System of Inshore Fishery Resources], National Institute of Aquaculture, Fisheries Agency of Japan, 15–17. (in Japanese)

21) Willemse, J. J. (1965): In Westelijk Nederland Voorkomende Soorten uit het Geslacht *Proteocephalus* (Cestoda) en hun Gastheerspecifiteit. Academisch Proefschrift, Amsterdam, 88 pp.

22) Willemse, J. J. (1969): The genus *Proteocephalus* in the Netherlands. J. Helminthol., 43, 207–222.

23) Yamaguti, S. (1934): Studies on the helminth fauna of Japan. Part 4. Cestodes of fishes. Jpn. J. Zool., 6, 1–112.